Energy, Mines and Resources Canada | Energie, Mines et Ressources Canada

CANMET

Canada Centre for Mineral and Energy Technology | Centre canadien de la technologie des minéraux et de l'énergie

DIFFUSION PROPERTIES OF A SYNTHETIC POROUS MATERIAL TO RADON GAS

J. BIGU

ELLIOT LAKE LABORATORY

AUGUST 1982

This document is an [illegible] interim report prepared for discussion and reporting purposes [illegible] represent a final [illegible] the opinion of the [illegible] for Mineral and Energy [illegible] (CANMET)

Ce document est un rapport [illegible] révisé et rédigé [illegible] fin de [illegible] documentation [illegible] définitive de [illegible] canadien de [illegible] des minéraux et de l'énergie (CANMET)

MICROMEDIA

OCT 27 1982

11 pp

MINERALS RESEARCH PROGRAM
MINING RESEARCH LABORATORIES
DIVISION REPORT MRP/MRL 82-77(TR)

DIFFUSION PROPERTIES OF A SYNTHETIC POROUS MATERIAL TO RADON GAS

by

J. Bigu*

ABSTRACT

The diffusion properties of a synthetic porous material to radon gas have been studied in a radon/thoron room calibration facility. The material tested is known under the commercial name Vyon. Experimental data indicate that for the thickness tested Vyon introduces a delay in the diffusion of radon of the order of 120 min in dry conditions, and substantially longer under wet conditions.

* Research Scientist and Radiation Project Leader, Elliot Lake Laboratory, CANMET, Energy, Mines and Resources Canada, Elliot Lake, Ontario, Canada.

INTRODUCTION

Radon gas measurements are usually carried out either by:

a) static or passive means, e.g., by transferring a sample into a suitable detector, such as a scintillation cell, under vacuum; or

b) dynamic means, e.g., by sampling the atmosphere under study continuously through the detector by means of a sampling pump.

The emanation of radon gas from, and through, materials is determined by diffusion and transport mechanisms. Diffusion of radon is governed by concentration gradients and is described by Fick's Law. Transport of radon gas depends on induced pressure gradients and is described by Darcy's Law. Both diffusion and transport mechanisms are important and depend on certain characteristics and properties of the material through which the gas travels including porosity, permeability and moisture content as well as some meteorological factors such as barometric pressure.

Because transport of radon gas is affected by pressure differentials in the material, sub-surface and surface radon gas measurements are best conducted by passive means. Measurements of radon at tailings sites and mine walls require the insertion of the radon detector, i.e., probe, into the ground or wall at the desired depth. However, the probe must be carefully protected from direct exposure to, or contamination from, unwanted radioactive solids, or solid-containing radioactive materials. This can be done by covering the detector with a suitable material permitting radon gas to diffuse into the sensitive volume of the detector while at the same time keeping radioactive materials, such as 'active' fines, away from it.

This report gives experimental data pertaining to a study on the diffusion characteristics of a porous material known commercially as Vyon,

distributed by Verge Enterprises (Toronto). The material was intended for use in conjunction with some radon gas measurements at tailings sites in the Elliot Lake area.

DESCRIPTION OF THE EXPERIMENTAL APPARATUS AND EXPERIMENTAL PROCEDURE

The experimental arrangement used for testing the diffusion characteristics of Vyon is shown in Fig. 1. This design was originally intended for driving the radon gas probes into the ground. It basically consists of a length of perforated PVC pipe surrounded by Vyon. A radon gas probe sits on the upper side of a pipe reducing fitting which couples a length of PVC pipe (of diameter slightly larger than the diameter of the probe) and the perforated pipe. An arrangement similar to that of Fig. 1, but without Vyon, was also used for comparison purposes. It will be referred to as the reference probe.

Radon gas measurements were done with soil radon gas probes of the passive type, model alpha METER 601, in conjunction with a data logger, model alpha LOGGER 650, both manufactured by Alpha NUCLEAR (Toronto).

Experimental data were obtained in a large radon/thoron room. The radon daughter Working Level, WL(Rn), was also monitored by a continuous Working Level monitor manufactured by EDA Instruments (Toronto) under the commercial name WLM-300.

The experimental procedure was as follows. The arrangement illustrated in Fig. 1 and the reference probe were flushed with clean air to remove all traces of radon gas in the sensitive volume of the probe. At a given time the two arrangements were placed side by side in the radon/thoron room and radon gas measurements were taken as a function of time.

Because tailings materials contain different amounts of water depending upon depth and meteorological conditions, it is important to test the diffusion

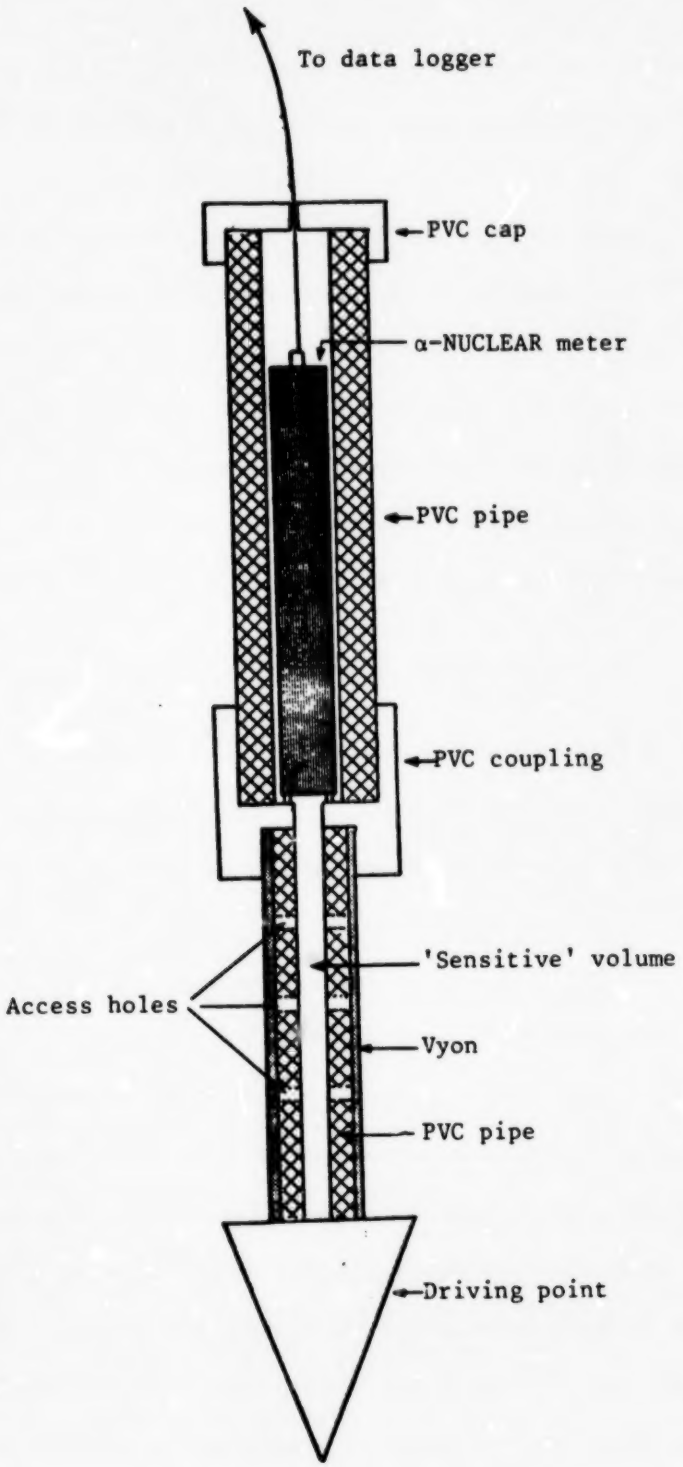

Fig. 1 - Experimental arrangement (probe) used to test the diffusion characteristics of the porous material Vyon.

characteristics of Vyon under several water-content conditions. A quite common situation in tailings piles is high-water content and/or water-saturated tailings at, or close to, the water table, and also during and/or after rainy conditions. In order to test the diffusion characteristics of Vyon under wet conditions, the arrangement of Fig. 1 was dipped in water overnight (only the Vyon/PVC perforated tube portion. The probe with wetted Vyon will be referred to as the wetted probe for simplicity). After removal from the water, radon diffusion measurements were conducted as described above.

The procedures indicated above were conducted for a period of several days for repeatability.

EXPERIMENTAL RESULTS AND DISCUSSION

Figures 2, 3 and 4 show the experimental results obtained. These figures were obtained under 'dry' and wet probe conditions, respectively. Also shown in these graphs are the radon gas levels, in α-count rate, and WL(Rn).

Figures 2 and 3 show that the response of the probe with Vyon is rather slow taking over 120 min to reach a steady-state or constant value. The radon gas level in the room remained essentially constant during the tests. Figure 3 also shows the results obtained with the reference probe.

Notice that the response of the probe without Vyon is almost instantaneous (sampling time was 3 min and 10 min for Fig. 2 and 3, respectively).

Figure 4 shows a comparison between a wetted probe and the reference probe. The behaviour of the wetted probe differs substantially from that under dry conditions, i.e., the inflexion of the graph is opposed to that of the dry probe, thereby indicating the retarding effect of water on the diffusion of gas through Vyon, compounded with the simultaneous evaporation of water from

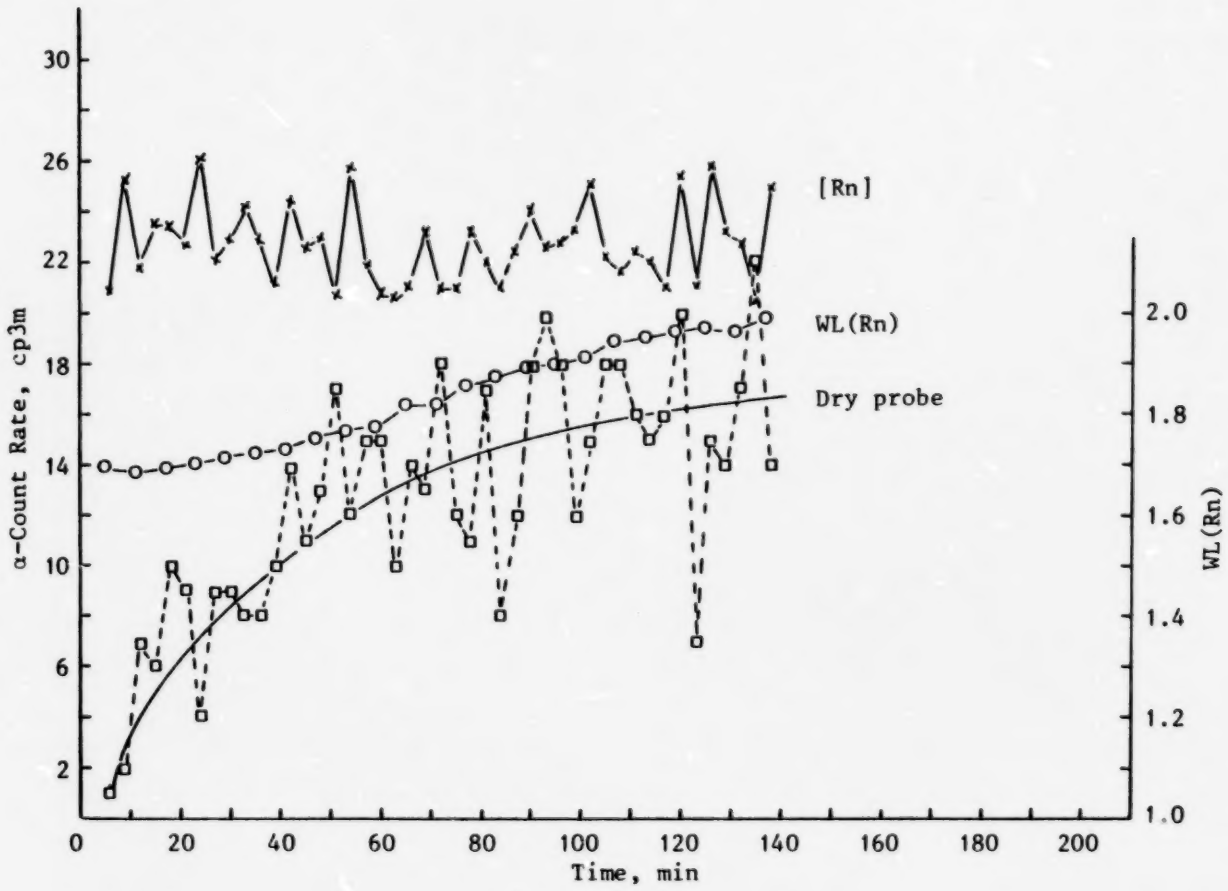

Fig. 2 - Radiation data versus time for: (a) radon room radon gas concentration, [Rn] in cp3m, obtained with the α-NUCLEAR meters, -x-; (b) WL(Rn) measured with the EDA WLM-300, -o-; and (c) radon gas concentration, cp3m, obtained with the dry Vyon probe --□-- (continuous line is the best fitted curve to the data). Note: cp3m stands for α-count in 3 min.

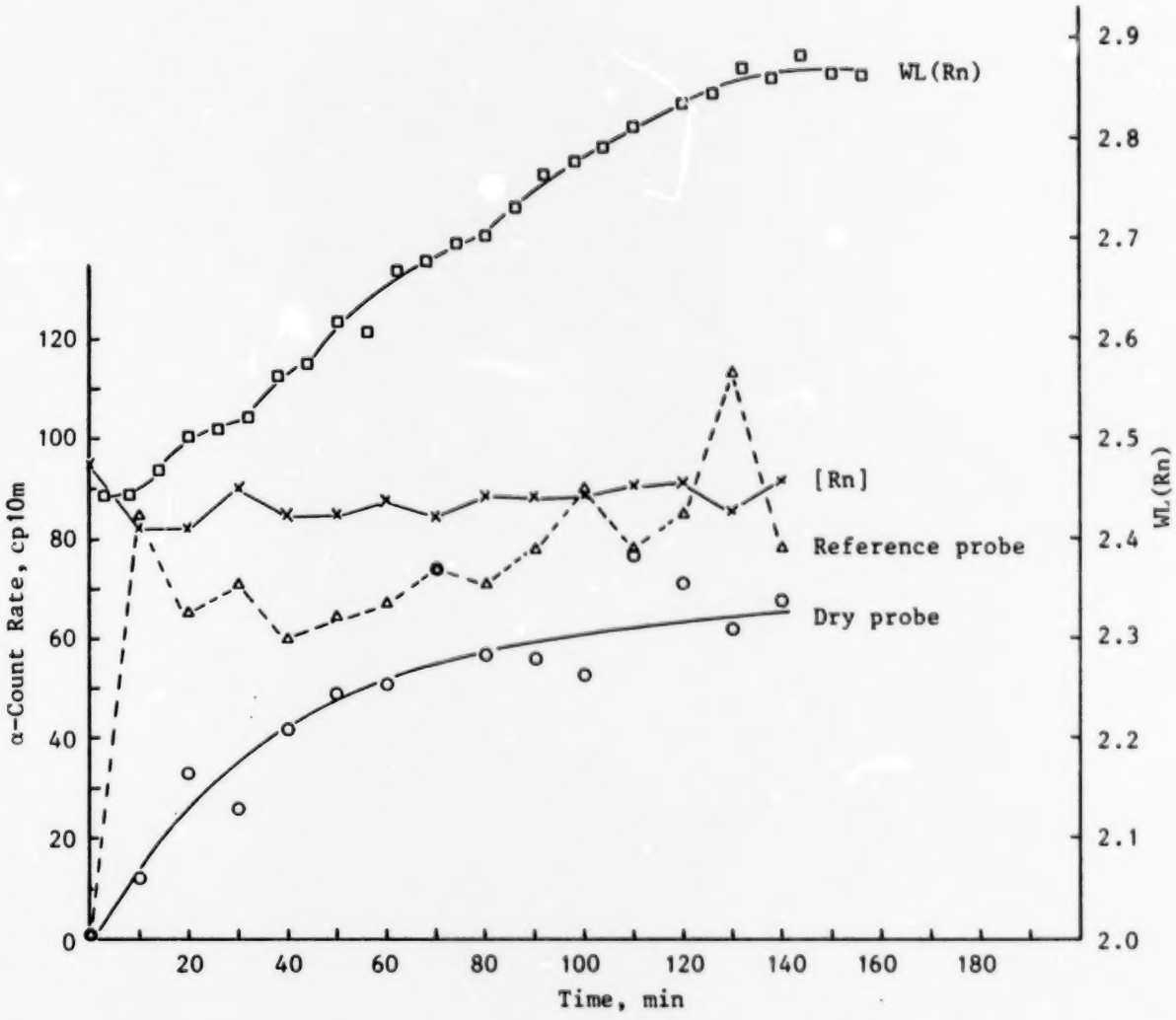

Fig. 3 - Radiation data versus time for: (a) radon room radon gas concentration, [Rn] in cp10m, obtained with the α-NUCLEAR meters, -x-; (b) WL(Rn) measured with the EDA WLM-300, -□-; and (c) radon gas concentration, cp10m, obtained with the dry probe, -o-, and the reference probe, -Δ-. Note: cp10m stands for α-count in 10 min.

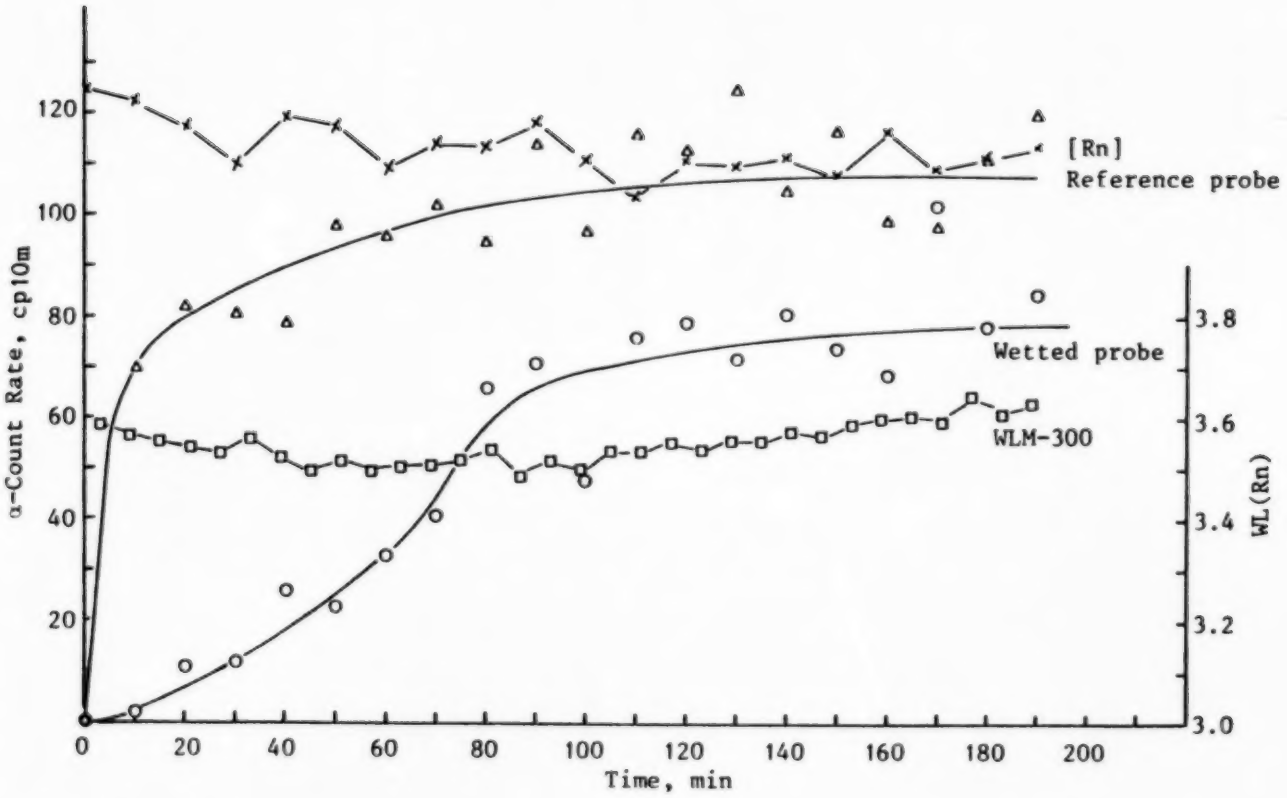

Fig. 4 - Radiation data versus time for: (a) radon room radon gas concentration, [Rn] in cp10m, obtained with the α-NUCLEAR meters, -x-; (b) WL(Rn) measured with the EDA WLM-300, -□-; and (c) radon gas concentration, cp10m, obtained with the wetted probe, -o-, and the reference probe, -Δ-. Note: cp10m stands for α-count in 10 min.

the material. (Note: the temperature inside the radon/thoron room was about 22°C, hence appreciable evaporation took place). Extrapolation of the data of Fig. 4 indicates that, as expected, the time taken for the wetted probe to reach a steady-state, final, level would be much longer than the 120 min approximately taken by the dry probe. As with the results of Fig. 2 and 3, the radon gas concentration remained fairly constant during this test. Notice that although the radon gas concentration remained essentially constant during the tests, WL(Rn) varied substantially during two of the tests reported here. This is so because WL(Rn) is highly dependent on the aerosol concentration, air flow conditions, concentration and type of trace gases such as NO, NO_2, and relative humidity (1 to 6). These factors affect the rate of deposition of radon decay products on surfaces, particularly the radon/thoron room walls, but they do not affect the concentration of radon gas. However, WL(Rn) is not important in the context of this study.

CONCLUSIONS

From the above discussion of the experimental data it may be concluded that the material tested would not be adequate for measurements where the radon gas emanation is likely to change rapidly over short periods of time. This situation might arise at Ra-226 tailings sites under abrupt changes in atmospheric conditions.

ACKNOWLEDGEMENT

The author is grateful to Mr. Chakravatti (Denison Mines) for providing the material (Vyon) with which the experiments were conducted. The author would also like to acknowledge the assistance of Mr. Grenier in some of the experiments, and useful discussions with Dr. N. Davé and Mr. T.P. Lim.

REFERENCES

1. Droullard, R.F. and Holub, R.F., "Continuous Working-Level measurements using alpha or beta detectors"; Report of Investigations RI 8237; U.S. Bureau of Mines; 1977.

2. Holub, R.F., Droullard, R.F., Ho, W., Hopke, P.K., Parsley, R. and Stukel, J.J., "The reduction of airborne radon daughter concentration by plate-out on an air mixing fan"; Health Physics, 36, p 497; 1979.

3. Holub, R.F., "Effects of an air moving fan on radon daughter plate-out in the DMRC radon chamber"; Proc Symp Radon Daughter Plate-Out Phonomena, pp 106-107 (University of Illinois); 1979.

4. Shreve, J.D., Jr. and Cleveland, J.E., "Effects of depressing attachment ratio of radon daughters in uranium mine atmospheres"; Am Ind Hyg Assoc J, vol 33, p 304; 1972.

5. Wrenn, M.E., Eisenbud, M., Costa-Ribeiro, C., Hazle, A.J. and Siek, R.D., "Reduction of radon daughter concentrations in mines by rapid mixing without make-up air"; Health Physics, vol 17, p 405; 1969.

6. Bigu, J., "On the effect of a negative ion-generator and a mixing fan on the plate-out of radon decay products in a radon box"; Division Report MRP/MRL 82-25 (J); CANMET, Energy, Mines and Resources Canada; 1982. To be published in Health Physics.